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Scenarios and Justification for Automated Vehicle Demonstration in Rural Minnesota

Frank Douma

Humphrey School of Public Affairs
University of Minnesota

Erin Petersen

University of Minnesota Law School
University of Minnesota

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16. Abstract (Limit: 250 words) Automated vehicles (AVs) have the potential to disrupt the current transportation system and culture. While experts debate the exact timeline, the question is likely a matter of when, not if. Therefore, communities of all kinds need to prepare for this future. Small urban and rural communities, in particular, could benefit from the development of the technology, as many of their residents are unable to drive due to age and/or disability. Automated technology could provide a cost-effective and efficient solution for these communities, but so far, most of the AV testing has been conducted in densely populated urban areas. This project provides justification for why rural and small urban communities should host AV demonstrations and how these communities can create a plan to do so. We accomplish this task by providing information about rural and small urban communities and by reviewing the current state of AV technology, the legal environment for AVs, and best practices from past and current AV demonstrations. We also engage with two small urban communities in Minnesota to gather information about real community needs, desires, and limitations.					
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FINAL REPORT

Prepared by:

Frank Douma
Humphrey School of Public Affairs
University of Minnesota

Erin Petersen
University of Minnesota Law School
University of Minnesota

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Center for Transportation Studies
University of Minnesota
University Office Plaza, Suite 440
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TABLE OF CONTENTS

CHAPTER 1: Introduction	1
1.1 The Emergence of Automated Vehicles: Developments and Benefits.....	1
1.2 Changing Demographics: Aging and Disabilities in Rural Areas	1
1.3 Vision for the Future of Transportation in Rural and Small Urban Communities	2
CHAPTER 2: Legal Landscape for AVs.....	4
2.1 General	4
2.2 The Emergence of Automated Vehicles: Developments and Benefits.....	4
2.3 Federal	4
2.4 State.....	4
2.5 Cities and Local Ordinances.....	5
2.6 Private Land	5
2.7 Data Privacy	5
2.8 Tort Liability	6
2.9 Conclusion	6
CHAPTER 3: Plan Considerations: Lessons Learned From Past and Current AV Demonstrations.....	7
3.1 General	7
3.2 Vehicle	7
3.3 Route	7
3.4 Schedule	9
3.5 Operation.....	10
3.6 Costs	10
3.7 Weather Hazards	10
CHAPTER 4: Demonstration Plan for Small Urban and Rural Communities	12
4.1 Introduction.....	12
4.2 Selecting Communities	12

4.3 Working with Communities.....	13
4.4 Initial conclusions	18
4.5 Conclusion	18
REFERENCES.....	19
APPENDIX A Sample Letter to potential communities	

LIST OF FIGURES

Figure 4.1 Proposed Route in Fergus Falls 13

Figure 4.2 Proposed Route in White Bear Lake 14

Figure 4.3 Updated route in White Bear Lake 17

Figure 4.4 Updated Fergus Falls route 17

LIST OF TABLES

Table 4.1 Selection Criteria 12

Table 4.2 Questions for communities 16

LIST OF ABBREVIATIONS

AV—Automated Vehicle

CAV—Connected and Automated Vehicles

NHTSA—National Highway Traffic Safety Administration

ADS—Automated Driving System

EXECUTIVE SUMMARY

Automated vehicle (AV) experts and manufacturers promise a future of carefree commutes, reduced need for parking, and improved efficiency. Many of these benefits may occur in densely populated urban areas; however, two of the most significant benefits, safety and mobility for those who cannot drive, can accrue nearly anywhere. Given that fatalities and serious injuries disproportionately occur in rural areasⁱ, and that these areas also have a disproportionate number of senior citizens and people with disabilitiesⁱⁱ, finding a model for developing and deploying these technologies in small cities and rural areas has the potential to greatly impact the lives of many.

This report discusses how to develop such a model. After reviewing the current legal and policy context for AVs, as well as lessons learned from past city demonstrations, the report articulates what questions and considerations communities must take into account when preparing for an AV demonstration. The report also includes data and input from actual small urban communities to produce a realistic demonstration framework that addresses real community needs. The report aims to educate readers so that by the time they finish reading it, they know what steps they need to take, what stakeholders they need to include, and what questions they need to ask to create a complete AV demonstration proposal for a rural or small urban community in Minnesota. While the model will focus on long-term benefits that may accrue from deployment of fully self-driving technology, the proposed demonstration will recognize that current AV technologies are not mature and have limits that show the potential of the technology without creating additional risk.

ⁱ National Highway Traffic Safety Administration. (2017, April). Rural/urban comparison of traffic fatalities. Retrieved from https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/12982-tsf_2015_rural-urban_comparison_040617_v3-tag.pdf

ⁱⁱ Housing Assistance Council. (2014, October). Housing an aging rural America: Rural seniors and their homes. Retrieved from <http://www.ruralhome.org/storage/documents/publications/rrreports/ruralseniors2014.pdf>

CHAPTER 1: INTRODUCTION

1.1 THE EMERGENCE OF AUTOMATED VEHICLES: DEVELOPMENTS AND BENEFITS

Self-driving cars (SDVs) or automated vehicles (AVs) are projected to disrupt the transportation industry. One conservative analysis estimates that full deployment of AVs may result in economic benefits of up to \$800 billion per year¹. The sources of these benefits include reduced oil consumption, reduced congestion, and improved access to retail and jobs². In addition to economic benefits, AVs may also produce social benefits, freeing up as much as 50 minutes a day from driving and reducing the number of fatal vehicular crashes³. As a result of these potential benefits, there is considerable momentum to bring about the wide adoption of AV technology.

While these benefits are encouraging, many likely will not be felt for several decades, with many industry experts citing 2040-2050 as the time when full self-driving capabilities and wide adoption will occur⁴. However, this does not mean no AVs roam the streets today. As of 2019, traditional automakers and startups have tested and demonstrated AVs in over 50 cities around the world⁵.

These companies aim to address a variety of transportation issues, from last-mile transit to freight⁶, resulting in a range of vehicle appearances, capabilities and levels of autonomy⁷. Some AVs look similar to traditional vehicles, such as Voyage's and Waymo's adapted Chrysler Pacifica Hybrid minivans^{8,9}, while others resemble airport shuttles, with no driver's seat or steering wheel in the vehicle¹⁰. In addition to differing appearances, the vehicles operate in varying levels of autonomy. SAE International, a global association of automotive engineers, developed a widely cited six-level scale of automation, where Level 0 means human drivers do everything and Level 5 means the automated driving system (ADS) drives in all circumstances and human occupants never operate the vehicle¹¹. While many predict Level 5 vehicles will not emerge until after 2025, volunteer passengers already experience Level 4 technology in Waymo vehicles in Phoenix¹² and in Level 4 automated microshuttles in Detroit and other cities¹³. Under certain road, weather and traffic conditions, vehicles with Level 4 autonomy essentially do all of the driving, and passengers do not monitor the vehicle¹⁴. The wide variety of vehicle types and autonomy illustrates the different roles AVs may play in the future of transportation.

1.2 CHANGING DEMOGRAPHICS: AGING AND DISABILITIES IN RURAL AREAS

Although most AV testing and demonstrations have thus far taken place in large urban areas¹⁵, AVs may greatly impact small urban and rural areas as well. These communities face safety and demographic challenges AVs are well suited to address.

Recent events, such as the fatal Uber crash in Tempe, Arizona,¹⁶ and several Tesla accidents¹⁷, stirred up questions concerning AV safety¹⁸; however, much of the testing strongly suggests that AVs may increase road safety. In 2017, automobile accidents resulted in 37,133 fatalities¹⁹, 94 percent of which can be linked to human error²⁰. Rural communities are disproportionately affected by this issue, as only 19 percent of the population lives in these areas²¹, yet 49 percent of fatal crashes occur there²². Since the vast majority of fatal crashes are caused by human error, the development of AV technology could drastically increase road safety. While AV technology currently has its limits, manufacturers and vendors continue to report decreased incidents of "disengagements"²³. The California Department of Motor Vehicles (DMV) considers a "disengagement" to be when an error in the technology is detected and when a safety driver must take back control of the vehicle²⁴. An example of this progress is that Waymo

decreased its disengagement rate from 0.09 per 1,000 self-driven miles in 2017 to one per 11,017 miles in 2018²⁵. While this does not mean that companies have eliminated the potential for crashes at this time, the trend toward fewer disengagements suggests that developers are getting closer to creating a vehicle that can operate in all conditions and do so without the potential for human error. If this occurs, AVs may significantly increase road safety.

In addition to safety benefits, AVs have the potential to increase mobility for those who currently cannot drive. This could significantly impact rural and small urban communities, as they are home to a large portion of the U.S. senior population and many people who have disabilities. Only 21 percent of the nation's population resides in rural or small-town census tracts, yet close to 25 percent of the senior population lives there²⁶. This number will likely continue to grow, because by 2035 older adults (65+) are projected to outnumber children for the first time in U.S. history²⁷, and 87 percent of adults age 65 and older report wanting to live the remainder of their lives in their current towns and homes²⁸. This will likely create pressure on social programs and public systems, including transportation. While 92.3 percent of people 50-69 years of age continue to hold driver's licenses, this number drops to 84.7 percent for those 70-84 years of age and 60.8 percent for those age 85 and older²⁹. On top of that, although many retain their driver's license, many older people, especially older women, report one or more reasons why they limit or avoid driving³⁰. This decrease in driving will likely increase the demand for affordable and convenient transit options.

Aging populations are also more likely to experience disabilities, which can present additional issues for mobility and public transit. In Minnesota, 7 rural counties with a high percentage of older residents report that at least 16 percent of their populations have a disability, and one 2017 report highlighted that the likelihood of having a disability increases from 1-in-10 for people age 18-64 to about 1-in-3 for those 65 and older³¹. While not all disabilities limit driving, a national survey indicated that 6 million individuals with a disability have difficulty getting the transportation they need, and about 560,000 disabled people indicate they never leave home because of transportation difficulties³². Given that rural and small urban communities typically provide fewer service hours and trips than urban systems³³, this may become a major issue for these communities in the near future.

The need for convenient and affordable transportation in these communities exists; however, providing rural and small urban transit services is often a challenge. Operating costs, driver availability and a lack of a significant ridership all lead to rural transit service being infrequent, covering limited areas and operating at high costs³⁴. According to a Minnesota Department of Transportation (MnDOT) report, in 2017 only 46 percent of rural and small urban transit services met the state guidelines for weekday service hours (9-12 hours per day), 4 percent met the guidelines for Saturday hours (9 hours per day), and only one community met the goal for Sunday hours (9 hours per day)³⁵. Introducing AV technology into these communities could provide a more efficient and lower-cost alternative to traditional public transit by increasing trip frequency and/or service hours without paying for or finding new drivers.

1.3 VISION FOR THE FUTURE OF TRANSPORTATION IN RURAL AND SMALL URBAN COMMUNITIES

AVs present an opportunity to potentially resolve pressing transportation issues, particularly those concerning the growing elderly population and people with disabilities. These populations may benefit greatly from AVs, but they may also have concerns about the technology, as demonstrated by a 2018 AARP poll in which 79 percent of baby boomers reported feeling scared to ride in an AV³⁶. Past AV demonstrations found that public engagement and education programs connected with public demonstrations often lead to increased public acceptance of the technology and the vehicles³⁷. This conclusion highlights the importance of educating the public about AVs and

allowing individuals to interact with the vehicles. AVs could significantly impact these communities in a significant way, and a demonstration could increase the likelihood of public acceptance from their residents.

CHAPTER 2: LEGAL LANDSCAPE FOR AVS

2.1 GENERAL

Before placing AVs on public roads, communities must first determine their legality. In his law review article “Automated Vehicles are Probably Legal in the United States”, law professor Bryant Walker Smith makes the argument that AV operation is already legal, because no international, federal or state laws explicitly prohibit it³⁸. He addresses the relevant laws, but rests his argument on the long-standing legal principle of that which is not prohibited is permitted³⁹. Due to this, relevant state and federal laws written without mention of AVs may be interpreted to allow for testing and operation of AVs⁴⁰. Despite this, states and the Federal governments may want more control over AVs and could promulgate AV legislation to do so.

2.2 THE EMERGENCE OF AUTOMATED VEHICLES: DEVELOPMENTS AND BENEFITS

States and the Federal government share the power to regulate vehicles and traffic. The Federal government is responsible for setting and enforcing vehicle safety standards, investigating and managing recalls, and educating the public about vehicle safety issues⁴¹. This means the Federal government controls what safety standards AVs must meet, and it can monitor automakers’ compliance with these standards. On the other hand, states have the power to license drivers, register motor vehicles, enact and enforce traffic laws, conduct safety inspections, and regulate insurance and liability⁴². Most relevant to AVs, states decide whether to license non-human “drivers” of automated vehicles and whether to register AVs to operate in their jurisdictions⁴³.

2.3 FEDERAL

Thus far, the Federal government has not made any binding decisions to regulate automated vehicle testing or operations. The National Highway Traffic Safety Administration (“NHTSA”) issued updated guidelines for automated vehicle testing in October 2018, but these guidelines reiterate numerous times that the guidelines are only “voluntary”⁴⁴. Further, in July 2018, the NHTSA deputy administrator made the statement that the agency has no plans to regulate the technology at this point⁴⁵. While these NHTSA guidelines may inform automakers of recommended practices, they do not have binding power and they do not prohibit AV testing or operations.

Congress has also not issued any binding laws regarding automated vehicle testing or operation. The Senate AV START Act ended before going to vote⁴⁶ after receiving pushback from several senators who cited concerns about safety standards, privacy and arbitration⁴⁷. Several senators have hinted that they will try again to pass AV legislation in 2019, but no action has been taken at this time⁴⁸. This inaction on the part of the Federal government leaves room for states to determine what limitations, if any, they want to create for AV testing and operation.

2.4 STATE

States have been much more active than the Federal government. As of 2019, 29 states and Washington D.C. had enacted AV legislation, and 11 state governors issued executive orders concerning the study, deployment and/or testing of AVs⁴⁹. The complexity of the legislation varies from state to state, with California creating a comprehensive regulation, application and documentation process and several other states simply defining terms and explicitly authorizing testing in the state⁵⁰. In 2018, Minnesota’s governor issued an executive order establishing a task force to

“study, assess, and prepare for...widespread adoption of automated and connected vehicles”⁵¹. The task force included several recommendations for the state in its final report issued in December 2018⁵², but as of Spring 2019, no binding action has taken place. Until the Federal government enacts legislation that preempts state AV legislation, AV regulations will likely continue to be inconsistent across state lines.

2.5 CITIES AND LOCAL ORDINANCES

Cities and towns may also control whether manufacturers may test or operate AVs on local roads. It depends on the state, but in Minnesota, the state authorizes cities to regulate certain traffic-related activities by passing local ordinances⁵³. Cities in Minnesota have the authority to create local ordinances to issue permits for residents to operate “mini-trucks, golf carts, ATVs or UTVs on designated roadways under the city jurisdiction”⁵⁴. Given the similarity between these vehicles and a low-speed automated shuttle, it is likely that cities have the authority to grant permission for testing AVs on their roads. However, it must be noted that operators of these vehicles must still comply with insurance, safety equipment, and sometimes state licensing requirements⁵⁵.

2.6 PRIVATE LAND

Finally, the area with the greatest latitude for granting permission to test AVs is private land. The operation of motor vehicles on private land is not subject to state or city regulation⁵⁶. While this allows owners of private land to permit testing or operation of AVs without restriction, it also exposes them to the greatest risk of liability. Many current AV state laws require that a manufacturer obtain a certain level of insurance before operating any vehicles⁵⁷; therefore, if private land owners decide to sidestep the restrictions imposed by these laws, then they may also sidestep the protections granted in them. This is an important consideration private land owners but think about before allowing AVs on their land.

2.7 DATA PRIVACY

In addition to general AV operating and testing laws, data privacy is another legal (and business) concern that arises with AVs. After the Facebook and Cambridge Analytica scandal emerged, a survey of Facebook users showed a 66% decline in trust that Facebook was committed to protecting the privacy of their personal information⁵⁸. This, along with other recent data breaches, may have customer trust repercussions for years to come. Baby Boomers are particularly sensitive to data security, with 79-84% responding that they were extremely unlikely to give away personal information⁵⁹. The National Council on Disability also raised concerns about AVs collecting data regarding passengers’ physical and/or mental disabilities and the potential negative effects of this information being given to insurers and/or marketers⁶⁰. Consequently, policy makers and automakers have an interest in ensuring that they keep riders’ private information secure.

Several U.S. Supreme Court cases may also affect the type of data protection companies may be required to provide. In *Riley v. California* (2014), the Court determined that searching through a cell phone without a warrant was a violation of 4th amendment rights, characterizing cellphones as “mini computers” filled with massive amounts of private information⁶¹. The Court’s use of the term “mini computers” left this ruling open to application to a range of technologies—potentially AV computer systems and fleet service applications that store passengers’ information. In the most recent data privacy Supreme Court case, *Carpenter v. United States* (2018), the Court held that the government needs a warrant to access a person’s cellphone location history, because cellphone records provide near

perfect surveillance⁶². Although the case addresses cellphone location data, the majority opinion makes it clear that the ruling applies to “information that can locate people generally, not just [cellphone location data] specifically”⁶³. Automated vehicles collect a significant amount of information about passengers’ driving habits and locations, potentially making the *Carpenter* ruling applicable. These Supreme Court rulings may therefore impact any future legislation regarding AVs and data privacy.

2.8 TORT LIABILITY

Finally, the introduction of AVs creates questions about tort liability in the event of a motor vehicle accident. Since AVs, depending on the level of autonomy, can operate without a human driver in the front seat, the question of who is “driving” becomes a more complicated question. Some automakers, such as Volvo, have pledged to accept liability if their vehicles cause an accident, but the question remains for the other vehicles⁶⁴. One solution states may employ is to distinguish between “operating” a vehicle and “operating a vehicle in a meaningful way”, where the former would preclude liability and the latter exposes a “driver” to tort liability⁶⁵. For example, inputting a destination request may not be considered operating in a meaningful way while taking control of a steering wheel would⁶⁶. Policy makers and legislators need to resolve this question so that police forces know who to ticket for negligent behavior and what party needs to pay for damages resulting from accidents.

2.9 CONCLUSION

In conclusion, the overall consensus is that AVs are already legal, but certain restrictions may limit testing and operation depending on the state. Communities planning AV demonstrations must be cognizant of their relevant state laws and must be aware that the Federal government may promulgate new laws or regulations that could preempt state laws and local ordinances. These considerations should not stop a community from developing a proposal plan, but must be a part of the overall plan and process.

CHAPTER 3: PLAN CONSIDERATIONS: LESSONS LEARNED FROM PAST AND CURRENT AV DEMONSTRATIONS

3.1 GENERAL

Once a community addresses the relevant legislation and legal limitations, it must then begin the process of developing the demonstration plan. Demonstration plans must include information about the proposed vehicle, route, schedule, logistics, and costs. In addition, communities should be aware of and address the potential hazards their demonstration might encounter, such as adverse weather. Communities should make these determinations based on their unique needs and resources, but lessons learned from past and current AV demonstrations may also inform these decisions. The following section outlines the major components of an AV demonstration plan and includes lessons learned from other demonstrations and studies.

3.2 VEHICLE

As stated above, AVs come in a variety of designs and levels of autonomy; therefore, communities must review the available models and determine which best fits their needs. Automated microshuttles are a popular option, appearing in demonstrations in Texas⁶⁷, Ohio⁶⁸, and the University of Michigan's campus⁶⁹. The shuttles' slow speeds and experience with demonstrations make this type of AV a good option for communities planning their first AV demonstration.

Several companies manufacture these shuttles, including EasyMile, whose vehicle MnDOT used for its 2018 Autonomous Bus Project⁷⁰ and Navya, whose vehicle runs in the Las Vegas pilot project⁷¹. The shuttles generally operate at a maximum speed of 35 mph and carry between 12 and 16 passengers at a time^{72,73}. One consideration communities need to take into account is that these vehicles require electric charge to function, and the charging requirements varying between vehicles⁷⁴. Most of these vehicles also have wheelchair ramps, making it a good option for communities hoping to serve elderly and/or disabled passengers⁷⁵.

3.3 ROUTE

AVs can operate in a variety of manners: door-to-door, mixed traffic, fixed route, etc.⁷⁶ When deciding in which manner to operate the shuttles, certain factors should be considered, including demand, current infrastructure, and technological limits. Past and current demonstrations as well as an overview of the status of the technology help to inform decisions regarding these factors.

When developing a route, an important question for communities to answer is what destinations the route should include. This will largely depend on the unique preferences of individuals in the communities and current transit gaps, but outside sources may also inform this decision. One recent study of senior citizens' use of a door-to-door mobility service found that for riders ages 65-84, the most common ride purposes were medical, social and consumer, in that order, and for riders 85+ the most common ride purposes were social, medical and consumer, in that order⁷⁷. Since this demonstration framework aims to serve the elderly population, the route should include stops for medical appointments as well as consumer shops and places for social engagement, such as a senior center or

coffee shop. Providing transit to medical appointments is especially important, because one study found that if an elderly person had a dependable ride, the likelihood of him or her scheduling an additional routine or chronic medical appointment increased by a factor of 2.3 or 2.4⁷⁸. This means those without dependable rides may not receive the medical care they need.

An AARP Public Policy Institute also surveyed people ages 50+ about what amenities they would like to have within a mile of their residence, and over 40 percent responded that they desired to have a bus stop, grocery store, pharmacy/drug store and a park within a mile of their homes⁷⁹. Assuming that the communities this demonstration will serve have similar interests, including these types of destinations should be considered.

Finally, after a year of testing, Waymo found that riders rode in AVs to the following locations, listed in order of frequency: work, restaurants, school, bars, car repair shops, retail stores, health salon or spa, supermarkets, electronics stores, and the gym⁸⁰. The demographics of rural and small urban communities may differ compared with Waymo's users, but the data Waymo collected contributes to the knowledge bank of how people may utilize AVs in everyday life. In the end, the stops included along the route will be up to the community, but the abovementioned data help establish a starting point.

Communities also need to consider current infrastructure when developing the route. First, it is important that the route operates along a road with two lanes running in the same direction. This could allow for one lane to be dedicated solely or primarily to the shuttle and prevent it from interfering with the flow of traffic⁸¹. Also, if the shuttle operates in mixed traffic, it runs the risk of frequent operation interruptions due to bicyclists, illegally parked cars, and unpredictable drivers⁸². Although it is not necessary to construct cement barriers between the lane and the public roadway, it is recommended that communities add clear signage and communication along the route to inform and remind pedestrians, bicyclists and other drivers that the lane should be reserved for shuttle operation⁸³.

Next, a community must determine where to locate shuttle stops. Several types of roads can be repurposed to serve as stops, including loading and turn-out areas, existing transit stops, areas where the curb meets the street, and street parking spots⁸⁴. For all of these options, communities must consider the impact of disrupting the current flow of traffic and the potential for public disapproval. For example, the Trikala, Greece demonstration saw public outcry following the removal of parking spots to create a dedicated lane⁸⁵. However, once residents began utilizing the shuttle service and understood its benefits, the disapproval went away⁸⁶. Therefore, despite initial public outcry, if the demonstration proves successful, any potential public disapproval may subside, as it did in Trikala⁸⁷.

Communities should also consider where to charge and store these vehicles⁸⁸. The charging facility should be located near the route to allow for convenient exits and entrances, and it must be adapted to the type of charging equipment needed for the shuttle. The ability to construct or repurpose an existing building near the route should be a consideration of communities as they determine where to place the route.

Finally, communities must consider the current limits of the technology when mapping a route. When confronted with an obstacle in its pathway, the shuttles often react over-cautiously, stopping in their paths until the obstacle departs⁸⁹. This is why a dedicated lane supports efficient operation, but it is also why left turns should be avoided if possible. If a left turn requires that the shuttle nudge out in front of other vehicles before an opportunity to turn emerges, the presence of the other vehicles ahead of it could make the shuttle stop⁹⁰. This is also why signalized intersections might benefit the shuttle, as traffic lights create a more predictable flow of vehicles. In addition to concerns about turns, communities must also pay attention to the clarity of the markings on the road. Although

innovators continue to progress the technology, current shuttles require clear lane markings, signs, and 3D maps⁹¹. As the technology improves, many of these issues may be resolved, but for now the route should run along clearly marked roads with adequate signage, few left turns, and signalized intersections.

3.4 SCHEDULE

The two main concerns communities must consider when choosing a service span are the cost of employing a person to monitor the shuttle and the charging frequency and time. Past and current demonstrations have operated at a variety of times, showcasing the possible flexibility of AV shuttle schedules. For example, the shuttle on the University of Michigan's campus runs Monday through Friday from 9:00 am to 3:00 pm⁹², while the shuttles in Lausanne, Switzerland operated daily from 7:45 am to 7:45 pm⁹³. The Swiss demonstration provided more service hours by using a six-shuttle fleet, which increased costs but also allowed the shuttles to charge during the span of service by rotating the shuttles used⁹⁴.

One of the benefits of using AVs for public transit is the ability to provide transit service without paying or scheduling a driver. Vulnerable passengers, such as the elderly and people with disabilities, may continue to require the assistance of a trained attendant, but eliminating the need to also pay a driver would ideally increase service hours and decrease public transit costs. However, these benefits will be postponed, as many state AV laws require that a human remain onboard the vehicle during testing⁹⁵. This stymies the benefits that may accrue for now, but these regulations will likely disappear as the safety of the vehicles is proven and the technology improves. This means that for now, communities need to factor in the costs of employing an on-board attendant, which can cost around \$22.50/hour, as documented by one AV cost survey⁹⁶.

In addition to costs of an on-board attendant, communities need to consider the charging requirements of the vehicles. Due to costs and demand, small urban or rural demonstrations will likely use only one shuttle, and the schedule will need to account for charging frequency, method and time. These factors vary between manufacturers, with Navya shuttles reporting an average operating time of 9 hours and EasyMile reporting that its shuttles can operate for 24 hours at a time⁹⁷. The Navya shuttles use inductive parking panels to charge and require 8 hours to charge⁹⁸. The EasyMile shuttle charges using an external cord and also requires around 8 hours to charge⁹⁹. Other shuttle manufacturers have additional and/or different charging requirements and limits. These constraints must factor into proposed schedules for AV demonstrations.

With this information in mind, several options exist for creating a schedule. For example, if a community chooses to use an EasyMile shuttle, the shuttle could operate for 24 hours at a time, but the schedule will need to account for the 8-hour charge time. Another potential option for the shuttles with inductive charging would be to operate the shuttle in on-demand mode and keep it in the charging facility until it receives a ride request. It is unclear if this is possible, but it could help eliminate the need to dedicate periods of time to charging. If it is not feasible, the span of service will be limited to the maximum operating span for that particular shuttle.

Communities should also consult residents about the schedule. As part of the Greater Minnesota Transit Investment Plan, the Minnesota Department of Transportation surveyed riders on what improvements they would like to see to the current system, and the main themes that emerged included longer weekday services hours, expanded Saturday service, and providing Sunday service¹⁰⁰. At the time of the survey, only five rural service providers offered Saturday and Sunday service, a gap that these shuttles could potentially fill¹⁰¹. Communities should also consider how

comfortable their residents are with technology if they intend to deploy an on-demand service without a set schedule, because these systems require a smartphone application and/or kiosks in order to generate ride requests¹⁰². The answers to these concerns will vary between communities and will depend on current transit services, budget and the population served.

3.5 OPERATION

AVs may operate more safely than human-driven vehicles, but the potential for accidents and breakdowns remain. The committee operating the CityMobil2 demonstrations in Europe discovered that arranging for a remote fleet management system to take control of the shuttle upon an interference with operation benefited the demonstration¹⁰³. This type of system allows for someone in a remote center to take over control of the shuttle to move it around an obstacle in its path or summon assistance from emergency personnel if necessary¹⁰⁴. The Lincoln, Nebraska proposal also includes a step-by-step process of how its fleet management system would address a variety of situations, including crashes and blocked routes¹⁰⁵. For the blocked route scenario, the fleet management service will check the vehicle's cameras and then either instruct the onboard operator to manually drive around the obstacle or take over control remotely to direct the vehicle around the obstacle¹⁰⁶. A system such as this will be critical for the proposed framework not only to increase efficiencies, but also to ensure that operators know the location and status of the vehicles at all times. With vulnerable passengers inside, operators need to be confident that they can easily take control of the vehicle if necessary.

3.6 COSTS

Details depend on the manufacturer, but there are several options available for purchasing or leasing an automated shuttle. First, the community hosting the demonstration can purchase the shuttle and pay for the annual operating costs. The estimates for prices range between \$220,000¹⁰⁷ and \$297,000¹⁰⁸. In addition to the initial costs, this community will also incur annual operating costs for maintenance, charging, and labor, which range from an estimated \$16,753¹⁰⁹ to \$47,000¹¹⁰. The community may contract with a transit management provider such as TransDev, Keolis, or FirstGroup¹¹¹. This type of arrangement would result in the transit management company owning the vehicle and providing maintenance, insurance, operations, and any employees needed¹¹². TransDev even offers a service to help adapt AVs to accommodate vulnerable populations, such as the elderly and those with disabilities¹¹³. The cost of this type of service depends on the number of vehicles and complexity of the demonstration, but one source reported that preliminary quotes for four vehicles was around \$725,000 per year¹¹⁴. Finally, the community may decide to lease the vehicle directly through the manufacturer. This option would require the city to manage the operations and provide employees, and according to one preliminary quote, it could cost around \$140,000 per vehicle per year¹¹⁵. In conclusion, several options exist for financing the vehicle and demonstration, and communities need to determine what their needs are when deciding what option to take.

3.7 WEATHER HAZARDS

Ideally the demonstration would be blessed with perfect weather for its duration; however, adverse weather conditions will inevitably occur and potentially impact the operation of the shuttles. Two past demonstrations witnessed the adverse effects of extreme weather on the shuttles. During the Lausanne demonstration, a heatwave forced the operators to run the air conditioning on-board nearly continuously, which resulted in the battery draining quickly¹¹⁶. In addition, dust from the accompanying drought interfered with the sensors of the shuttles¹¹⁷. One source

reports that the hours of operation drop from around 8-10 hours to around 3-4 hours when climate control is running¹¹⁸. Communities planning on hosting demonstrations during hot summer months should consider these hazards. Winter conditions also present challenges for these shuttles. The Minnesota Autonomous Bus Pilot found that falling, blowing or loose snow causes the shuttles to stop or slow down and snow banks that fall into the shuttle's pathway force it to stop¹¹⁹. Sub-zero temperatures and running the heater also drains the battery more quickly and negatively impacts the vehicle operation¹²⁰. All in all, extreme weather, both cold and hot, negatively impacts the operation of the vehicles.

These potential impediments may force communities to adapt their schedules in accordance with the weather. Likely, the shuttles will not be able to operate with passengers during extreme heat, cold, and snow storms; however, these hurdles also provide opportunities for manufacturers. In order to develop solutions to these problems, manufacturers need to conduct tests during adverse conditions. This opportunity could be a marketing point for communities trying to attract AV companies for partnerships and testing.

CHAPTER 4: DEMONSTRATION PLAN FOR SMALL URBAN AND RURAL COMMUNITIES

4.1 INTRODUCTION

As mentioned above, the exact details of an AV demonstration plan depend on the unique needs and constraints of the hosting community. To understand some of these potential details, the research team worked with two Minnesota communities to create hypothetical demonstration plans.

4.2 SELECTING COMMUNITIES

The research team sought out rural and small urban communities with a significant population of senior residents and/or people with disabilities. It was important to also keep in mind during this process road and route considerations required for a feasible demonstration. The team created the following list of criteria to help identify potential communities:

Table 4.1 Selection Criteria

Community Criteria	Road Requirements
<ul style="list-style-type: none">• Rural (<2500) or small urban (2500-50,000) population• Interest from community members and stakeholders• Large population of elderly residents, particularly those who no longer drive• Limited current transit service, gaps in “in-town” transit• Potential loops of 1-3 miles along local city roads• Destinations of interest for elderly and/or people with disabilities<ul style="list-style-type: none">◦ Medical, social and consumerⁱ; 40 percent of respondents age 50+ want a bus stop, grocery store, pharmacy/drug store and a park within a mile of their homesⁱⁱ• Existing transit stops or areas along the route easily convertible to transit stops (streets must accommodate wheelchairs)• Charging stations	<ul style="list-style-type: none">• 10-foot wide lanes, no speed bumps, appropriate clearance (individual vehicle needs below), asphalt or concrete surface• Two-lane roads, preferably a one-way, so that one lane can be dedicated to the shuttle• Cannot operate on roads with speed limits above 35 mphⁱⁱⁱ• Should limit to local/city roads (no state roads or highways)• Limited number of left turns• Stops along the route that can be converted into transit stops (accommodating for wheelchairs and limit disruptions to the flow of traffic)
<p>ⁱ Bird, D, Freund, K., Fortinsky, R., Staplin, L., West, B., Bergen, G., & Downs, J. Driving Self-Regulation and Ride Service Utilization in a Multicommunity, Multistate Sample of U.S. Older Adults. 2016 Aug. 30.</p> <p>ⁱⁱ Harrell, R., Lynott, J., Guzman, S., & Lampkin, C. What is Livable? Community Preferences of Older Adults. April 2014. AARP Public Policy Institute.</p> <p>ⁱⁱⁱ https://www.lmc.org/media/document/1/cityregulatoryfunctions.pdf?inline=true</p>	

These criteria narrowed the search to 11 communities within Minnesota, and two communities signed on to create demonstration plans: White Bear Lake and Fergus Falls.

4.3 WORKING WITH COMMUNITIES

As part of the proposal to potential communities, the research team created maps of potential routes that addressed transit needs and operated within the limitations of current AV technology (e.g., limited left turns, signalized intersections, and the possibility of dedicating a lane to the vehicle). Included on these routes were destinations such as senior centers, grocery stores, and medical clinics and pharmacies. The proposed routes for the communities involved with the project were as follows:

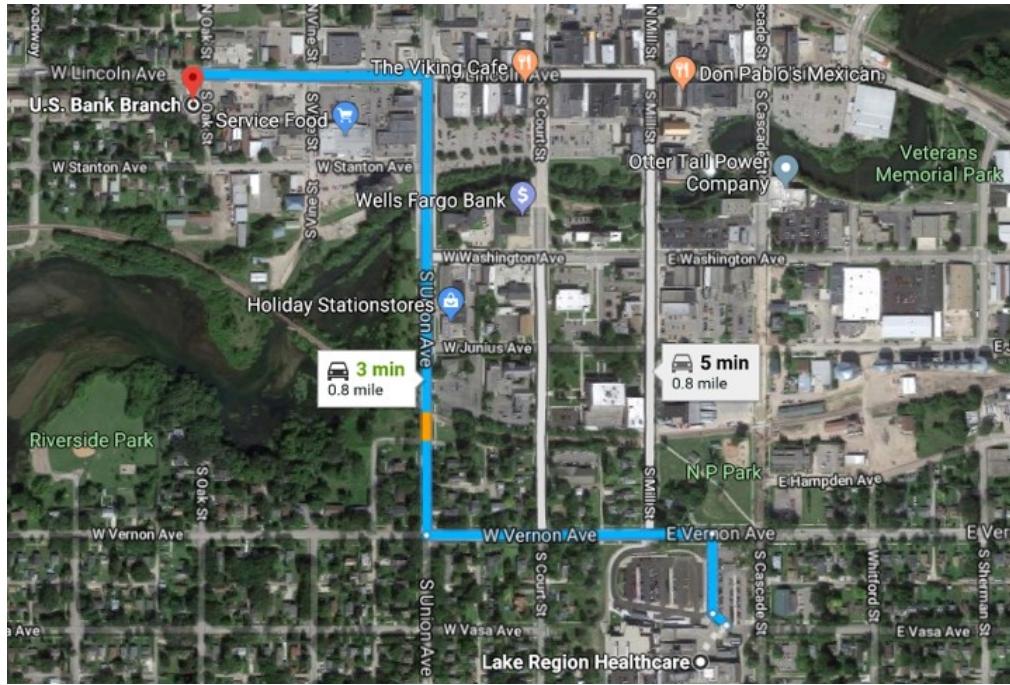


Figure 4.1 Proposed Route in Fergus Falls



Figure 4.2 Proposed Route in White Bear Lake

These maps served as an important starting point for discussions with the interested communities and helped community stakeholders understand what a potential route might look like.

This foundation was particularly important for initial discussions; before route specifics could be discussed, community stakeholders had to agree that this project was worth dedicating community time and expertise to. This process varied between the two communities. In one community, the research team presented to the board of the Chamber of Commerce, the local Rotary club, and others before a task force of local representatives was assembled for the project. The task force then presented to the City Council for its approval of the project. These meetings were not solely for gaining approval, but also for introducing the technology and project to local residents. In the second community, the research team spoke almost exclusively with the city engineer and attended one City Council work session, during which the council moved to approve the project. This scaled-back approach may be due to the smaller size of the community and that the local ordinances allow the city engineer to make all permitting and street/lane closure decisions. Since the city engineer headed the communication between the city and the research team, it expedited the process. These differing approaches highlight how communities address opportunities in a variety of ways, but in both circumstances, having a proposed route map helped local stakeholders understand the project and it served as a starting point for the work.

In addition to securing approval for the project, the community engagement also resulted in a diverse group of people coming together to work on the project. In one community, the task force for the project consisted of

representatives from the chamber of commerce, the school district, a local transit provider, and the City Council. Engaging with people with an array of perspectives resulted in a demonstration plan inclusive of a variety of priorities and considerations. For example, the representative from the local transit provider knew of the in-demand destinations for seniors in the community as well as current transit gaps, while the representative from the school district proposed opportunities for students to become involved with the project. This diversity of experiences and ideas assisted in the creation of a realistic proposal plan that accommodates and addresses the needs of many within the community.

Once a task force or point of contact was established in both communities, the research team began asking the specific questions. These questions were as follows:

Table 4.2 Questions for communities

Schedule/Route	Infrastructure
<ul style="list-style-type: none"> • What trip purposes will be served? • Where are the main destinations? • What time of day best serves priority users (i.e. seniors and those with disabilities)? • will the route be linear or circular? • will the vehicle operate on a consistent schedule or be on-demand? • can the route be altered to take the shortest route to the requested destination, or does the vehicle run on a fixed-route? • how will the schedule be communicated to the riders? • Will riders need to request a ride using a mobile application? • Will the community charge a fare for rides? 	<ul style="list-style-type: none"> • Are there specific infrastructure updates the vehicle requires (e.g. DSRC technology, updated signage, etc.)? • Where will the city store and charge the vehicle? • What sort of charging station does the vehicle require? • Is it possible to dedicate a lane to the vehicle, or will it have to operate in mixed traffic? • Are there stoplights or four-way stop signs at intersections the vehicle crosses?
Partnership Considerations	Risks
<ul style="list-style-type: none"> • How will local emergency responders need to react to a vehicle accident? • What type of vehicle with the community require? • How will the community acquire the vehicle (e.g. lease, contract, purchase)? • Will the demonstration require a company or agency to manage the vehicle operations? Costs? • Will an attendant need to be onboard the vehicle during operations? Costs? • Is there a current transit system the vehicle can supplement for frequency of trips and hours of operation? 	<ul style="list-style-type: none"> • Will the vehicle be able to operate in hazardous conditions, such as adverse weather? • What potential risks are there to operation, including those related to public safety, technical risks, costs and public acceptance? • What specific hazards need to be accounted for (e.g. railroad crossings, low-maintenance roads, narrow bridges, blind intersections)?
Legal Considerations	
<ul style="list-style-type: none"> • Who will need to approve the demonstration plan? • Are there any local ordinances or regulations that could interfere with a demonstration? • Are there any relevant state laws that might limit AV testing and/or require certain things before testing may occur? • Are the vehicles allowed on state roads as well as city roads? 	

This list of questions was created after reviewing existing AV demonstration plans, as well as the current legal and policy environment for AVs in the United States. Engaging with a diverse group of people with varying expertise streamlined the process of answering the questions, and the list forced the group to consider all of the different aspects of a possible demonstration plan. These questions led to the modification of the initial proposed routes in both communities. The city manager's team in White Bear Lake approved that community's new route, while the city engineer's team in Fergus Falls still needs to approve the route for Fergus Falls. The new routes follow:



Figure 4.3 Updated route in White Bear Lake

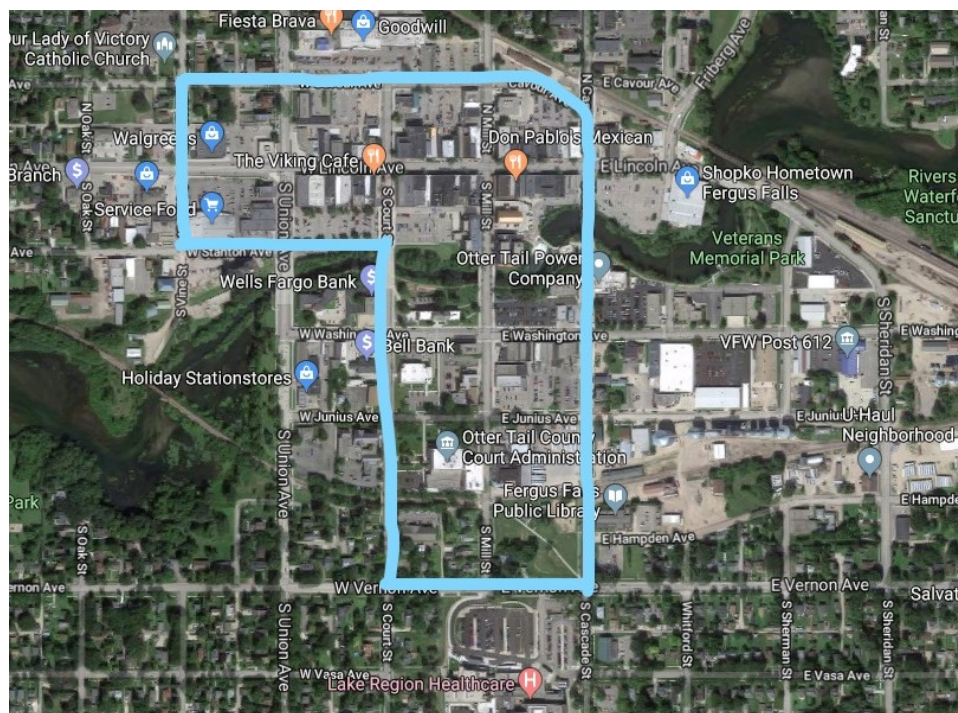


Figure 4.4 Updated Fergus Falls route

The updated route in White Bear Lake includes new destinations to accommodate the senior population, such as senior residences and the YMCA, and slower, less-trafficked roads. The Fergus Falls route modifications include movement to less-trafficked roads with the possibility of restricting a street to make room for a dedicated lane. In addition, the new route passes by a planned downtown revitalization development project.

4.4 INITIAL CONCLUSIONS

While work remains, two significant initial conclusions became apparent through working with these communities. First, when creating an AV demonstration plan, it is important to engage with a wide range of local representatives who have differing roles and experiences. Their perspectives help create a comprehensive plan that addresses the needs of the entire community, and it makes the process smooth and quick. Second, focusing on community outreach leads to an enthusiastic community and group of stakeholders. Automated vehicle technology is new and may concern those unfamiliar with it. By presenting on the technology's developments, current testing and benefits, the research team was able to clarify concerns of residents and help them understand how the technology could benefit their community and interests. As the project continues, additional conclusions will likely present themselves, but for now, these two conclusions stand out as the most significant takeaways.

4.5 CONCLUSION

In conclusion, automated vehicles have the potential to significantly benefit rural and small urban communities, and the opportunity to bring the technology to these communities exists now. The review of the state of the technology, current AV regulations, and best practices from current or past demonstrations reveal that it is possible for these types of communities to host an AV demonstration today. The technology has its limits, and communities must look to their state's AV legislation, if applicable, for any criteria for or prohibition of testing. In addition, the information gathered from the two small cities in Minnesota involved in the research will serve to create a framework for communities across the United States to use when developing their own AV demonstration plans. Automated technology may produce numerous benefits for small urban and rural communities, and this project provides the steps to take to introduce the technology into communities today.

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APPENDIX A

SAMPLE LETTER TO POTENTIAL COMMUNITIES

Email:

Re: Humphrey School of Public Affairs—Community Interest in Automated Vehicles

Good Morning,

My name is Erin Petersen, and I am a research assistant with the State and Local Policy Program (“SLPP”) at the University of Minnesota Humphrey School of Public Affairs. I am reaching out, because we have identified your community as a potential host for an automated vehicle (“AV”) demonstration and would like to know if you would be interested in working with SLPP to develop a proposal. At this time, the objective of the research is not to place an AV on the streets, but to develop a detailed plan for how a small urban or rural community may be able to do so in the future.

Driving this research is the hope that the information gathered will help ensure that the needs of communities outside of major cities, especially those with large populations of senior citizens and/or people with disabilities, are considered during the development of AV technology and policies.

I have attached to this email a document with an overview of our research, our objectives for working together, potential route considerations, and a list of other cities’ demonstrations/proposals for your reference. If you are interested in speaking with SLPP about this opportunity, you can reach us by responding to this email or calling Frank Douma, the director of SLPP, at 612-626-9946.

If there is someone else in your community with whom I should speak about this opportunity, please let me know. Please also feel free to forward this message to other community stakeholders if you believe that would be helpful.

I look forward to hearing from you soon. If you have any questions, please let me know.

Sincerely,

Erin Petersen

Important: The purpose of this email is to explain our research and inquire about interest in the project. This is not a request for a proposal or an offer to engage in work together, and a response to this email will not guarantee a promise to work together.

Attachment:

Overview

The potential benefits of automated vehicles (“AVs”) have been discussed at length, including the reduced need for parking, increased opportunity for vehicle-sharing and improved efficiency. Most of those benefits will occur in densely populated urban areas; however, two of the most significant benefits, safety and mobility for those who cannot drive, can accrue nearly anywhere. By solely focusing on major urban areas, AV manufacturers run the risk of developing a technology that does not address the needs of other communities.

Our research aims to address this potential issue by bringing small urban and rural communities into the conversation. By teaming with community officials, local residents, and AV manufacturers/vendors, we hope to develop both a plan for demonstrating the technology in these communities as well as an understanding of the obstacles that must be overcome before full deployment is a viable option. After reviewing current state and federal laws along with past and current AV demonstrations, we created an initial framework for proposing an AV pilot program. This will act as the basis for our work going forward, but we need input from real communities in order to produce a realistic plan.

If AV manufacturers hope to spread the benefits of the technology to the entire population, they will need input from diverse communities, including small urban and rural communities. This research and demonstration proposal will provide important data to help encourage the development of AV technology that considers the unique needs and challenges of communities outside of major cities.

Objectives

- Engage community leaders to determine current community transit needs
- Work with the city engineer and other stakeholders to determine on what streets the route could run and what infrastructure updates are necessary, if any
- Review local ordinances and determine if they present any hurdles for an AV demonstration
- Communicate with local residents to receive feedback on what destinations should be included and what concerns they have regarding the technology
- Develop a detailed proposal for an AV demonstration to take place within the community

Potential Route Considerations

- The main target population for this demonstration is those who cannot drive themselves due to age, disability or other limitation; therefore, the destinations should include those most important to these groups (e.g. medical clinics, pharmacies, grocery stores, senior centers, etc.)
- AV technology is currently in a state of development, meaning there are some limits to how and where the vehicles can operate. Ideal road conditions for a route include:
 - Asphalt or concrete surfaces
 - Two-lane roads, preferably with one-way traffic direction, so that one lane can be dedicated to a shuttle
 - A speed limit of no more than 35 mph

- Limited number of left turns
- Stop signs or signalized traffic light at intersections with turns
- Route length of 1-3 miles roundtrip
- To help envision what a route might look like, we created this potential route plan for your community:



(Connecting the White Bear Area Senior Program with a shopping area)

Questions Needing Answers

- What areas in town would see the most use of the vehicle (e.g. shopping areas, connections to senior centers, last-mile transit, etc.)?
- What infrastructure changes and/or additions would be necessary for the route?
- Are there current roads that could support an AV route (e.g. dedicated lane, speed limit of 35mph, etc.)?
- What potential risks are there, including those related to public safety, regulations, approval, technical risks, costs and public acceptance?
- What is the likelihood that those risks will occur? How should the risks be mitigated, and who is the party responsible for mitigating the risks (e.g. responders, MnDOT, etc.)?
- What partners will the project require (e.g. vehicle vendors), and what are their roles and responsibilities?
- Are there any local ordinances or regulations that could interfere with a demonstration?

Other Demonstrations

- According to the Bloomberg Aspen Initiative on Cities and Autonomous Vehicles, as of October 2018, 144 cities around the globe have either hosted or are preparing to host an AV demonstration
- If you are interested in learning more about other demonstrations and proposals, you can look through the following examples:
 - **Lincoln, Nebraska:** <https://lincoln.ne.gov/city/ltu/startran/micro-av/pdf/lincoln-vision-2018.pdf>
 - **University of Michigan, Ann Arbor:** <https://mcity.umich.edu/shuttle/>
 - **Grand Rapids, Michigan:** [https://www.mlive.com/news/grand-rapids/index.ssf/2018/09/first look at driverless shutt.html](https://www.mlive.com/news/grand-rapids/index.ssf/2018/09/first%20look%20at%20driverless%20shutt.html)
 - **Bloomberg Philanthropies' Map of Host Cities:** <https://avsincities.bloomberg.org/>

If you have any questions or concerns about the project, you can reach us by emailing Erin Petersen at pet01521@umn.edu or calling Frank Douma, the director of SLPP, at 612-626-9946.